

BELLCOMM, INC.

SUBJECT: ALSEP Derived Contingency Science  
Case 340

DATE: August 23, 1968

FROM: M. T. Yates

ABSTRACT

A passive seismic contingency experiment should be developed for the first lunar landing if and only if a one year lifetime (at least) can be guaranteed. All other specifications (except sensitivity) should be subordinated to the lifetime requirement. That is, dynamic range, temperature control, duty cycle, band-width, and command capability, can be sacrificed, if necessary, in order to develop a long life instrument within the time available. Since the PSE is in the final stage of flight acceptance testing, the development of a contingency seismometer would have little effect on the ALSEP schedule.

Due to the rigorous requirements for a successful corner reflector experiment and the lack of extensive technological experience in this area, it is considered unlikely that an acceptable instrument could be developed in time. The development of the ALSEP LR<sup>3</sup>, which is still in its infancy, should not be impeded by a crash program to build a contingency reflector experiment which may be of marginal utility.

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## MEMORANDUM FOR FILE

### 1.0 INTRODUCTION

The Planetology Subcommittee has recently recommended the development of a contingency scientific package to be used in the eventuality that the Apollo ALSEP does not fly on the first lunar landing mission. The experiments most often mentioned in this connection are a seismometer and a corner reflector. In this memorandum I examine the rationale for such a contingency program in relation to the scientific goals of these experiments and the presently conceived lunar exploration program.

### 2.0 BACKGROUND

The ALSEP passive seismic experiment (PSE) represents the third attempt to get a seismometer on the moon. Both the Ranger and Surveyor programs began with planned seismic experiments which were never realized. The ALSEP PSE is an outgrowth of these earlier instruments and represents a highly sophisticated state-of-the-art instrument which measures three components of long period (10-15 sec) ground motion and one component (vertical) of short period (1-10 sec) ground motion. The PSE requires 80% of the entire ALSEP data rate and is unquestionably the highest priority experiment.

By its nature the PSE is a network/observatory type experiment. That is, the full potentialities of the experiment are not realized unless simultaneous operation of many (>3) instruments for an extended period of time is achieved. Although one successful seismic station on the moon will undoubtedly provide a quantum jump in knowledge of the moon's seismicity, this information would be analogous to what was known of the Earth in the early 1900's.

A contingency seismic experiment, as presently conceived, would consist of a Surveyor seismometer with associated electronics, a power subsystem of solar panels possibly with a Surveyor battery for nighttime operation, and a data subsystem with amplifiers, signal conditioners, transmitter and antenna. Most of these components have been designed and built for the Surveyor program and would merely need minor modifications and

qualification testing. The short time available (9 months) for the development of a contingency science package requires that new design effort be kept to a minimum.

The second experiment recommended for contingency science is the corner reflector or Lunar Ranging Retro-Reflector (LR<sup>3</sup>). Unlike the PSE, this experiment is recommended because of its relative simplicity (it is totally passive) and the fundamental nature of the questions it may answer (dynamic interaction of the earth-moon, nature of gravity, continental drift). To gather data on these questions, the corner reflector is emplaced on the moon and laser ranging to it is carried out from one or more earth stations over a long period (3 to 10 years). The optical performance of the reflector is critical since the attenuation from transmitted pulse (energy) to received signal is -180 db, and the long term performance of the reflector material can be verified only in actual lunar operation.

At present, the LR<sup>3</sup> is only potentially an ALSEP candidate experiment, since a contract has not been signed for experiment development nor has a flight assignment been made. If the present science payload schedule is adhered to, the LR<sup>3</sup> will fly on the 5<sup>th</sup> mission at best. However, since the experiment is passive, it can be configured to fly independently of, and in addition to ALSEP, if weight and volume constraints permit.

Unlike the seismic experiment, a contingency LR<sup>3</sup> has little pre-existing hardware or design effort to utilize. A few high precision cube corners have been fabricated, but the packaging, thermal control, and mechanical subassembly, exist only as untested concepts.

In an effort independent of the ALSEP LR<sup>3</sup>, the Air Force Cambridge Research Laboratory has manufactured a large (11 cm) corner reflector with incorporated packaging and thermal control. Although testing of this instrument may validate it as an acceptable package to achieve the objectives of Eckhardt's Category I experiment, it should not be confused with the ALSEP LR<sup>3</sup> experiment. The AFCRL reflector will not satisfy all the objectives of the ALSEP experiment nor was it designed to do so. The Eckhardt experiment is of interest primarily to geodesists and cartographers (but including measurements of lunar physical librations, of interest to geophysicists) while the ALSEP experiment (C. Alley, Principal Investigator) incorporates a superior optical and thermal design to achieve a wealth of fundamental science objectives. (ephemeris time, lunar radius and orbit, secular motions of the earth stations, gravitational waves). Also, the Eckhardt instrument is of sufficiently different

design from the Alley LR<sup>3</sup> that any thermal-vacuum or solar optical testing of the Eckhardt corner will be of little value to the ALSEP LR<sup>3</sup> development.

### 3.0 RATIONALE FOR A CONTINGENCY SCIENCE PACKAGE

The most obvious advantage of a contingency science package is the time gained. The present S-V launch schedule calls for launches on 3 month centers. Program options now being examined call for this to be stretched to 6 months and possibly a year for the later missions to allow for more efficient use of the data gathered on early missions. Therefore, a contingency seismic experiment would provide data 3 to 6 months early and a contingency corner reflector might fly 3 years ahead of its ALSEP counterpart. This assumes that ALSEP will fly on the second and subsequent missions, which is probable since payload capability has always been conservatively estimated for the first flight of a spacecraft.

Although flying a contingency seismometer and/or corner reflector would place a scientific instrument on the moon significantly ahead of a no contingency program, it does not follow that the objectives of the experiments will be satisfied that much sooner. A widespread net of seismic observatories would have the capability to provide data on many of the basic questions concerning the moon's origin and present state. One seismometer, on the other hand, whether ALSEP PSE or Modified Surveyor, will in all probability be able to measure only the seismic noise level and the general seismicity of the moon. These data would be useful as engineering inputs for modifications of future seismometers (gain and sensitivity adjustments). However, the first four ALSEP flight seismometers will have been built and tested by the time any contingency package could be flown, and it is unlikely that even a 6 month lead time would be sufficient to allow such modifications in flight hardware.

In order to significantly advance the seismic exploration of the moon, a contingency seismometer must be able to survive and operate on the moon for at least one year. If the power subsystem of the experiment can be designed to maintain the seismometer for this long, even at a 50% duty or less (i.e., only daytime operation), then such a contingency package would be of great value in the early establishment of a multiple station net. To accomplish this function, the seismometer need not be sophisticated; the Surveyor instrument would be quite adequate.

The LR<sup>3</sup> experiment, on the other hand, has no firm requirement for a network of stations. A corner reflector contingency experiment may, therefore, be of limited utility.

Unlike the seismometer, which has 50 years of development to rely on, corner reflectors are a relatively new idea. Corners of sufficiently high precision to allow ranging to the moon are pushing the state-of-the-art. The lack of broad technological expertise in this area and the unknown long term effects of solar radiation on the optical performance of the corners make the reliability of the design relatively uncertain and predictions of the performance of the instrument extremely difficult.

Because of these uncertainties and the fact that only one corner reflector is required on the moon (although two at different longitudes and possibly one at a high latitude would be of value), the corner reflector experiment, when flown, should be as near-optimum as present technology allows. The present state of the LR<sup>3</sup> development program is such that this could probably not be achieved in the 9 months available for development of a contingency science package.

#### 4.0 CONCLUSIONS

A passive seismic contingency experiment should be developed for the first lunar landing if and only if a one year lifetime (at least) can be guaranteed. All other specifications (except sensitivity) should be subordinated to the lifetime requirement. That is, dynamic range, temperature control, duty cycle, band-width, and command capability, can be sacrificed, if necessary, in order to develop a long life instrument within the time available. Since the PSE is in the final stage of flight acceptance testing, the development of a contingency seismometer would have little effect on the ALSEP schedule.

Due to the rigorous requirements for a successful corner reflector experiment and the lack of extensive technological experience in this area, it is considered unlikely that an acceptable instrument could be developed in time. The development of the ALSEP LR<sup>3</sup>, which is still in its infancy, should not be impeded by a crash program to build a contingency reflector experiment which may be of marginal utility.

This memorandum is concerned solely with ALSEP derived contingency experiments. The rather negative conclusions should not be taken to mean that contingency science is not worth doing. Rather contingency science is worth doing if the experiments will result in a significant increase in data return without adverse effects on the ALSEP program. Lastly, ALSEP contingency science must be weighed against other contingency science such as an expanded geology investigation. Although

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this would certainly be an easier contingency program to implement, it would be a lower priority experiment than a long lived contingency seismometer.

*M. T. Yates*

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**BELLCOMM, INC.**

Subject: ALSEP Derived Contingency  
Science

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